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EXPERIMENTAL ANALYSIS OF FRICTION STIR WELDING OF DISSIMILAR ALLOYS AA7075 AND MG ZE42 USING BUTT JOINT GEOMETRY

A. K. DARWINS[1], M. SATHEESH[2] & G. RAMANAN[3]

[1,2]*Department of Mechanical Engineering, Noorul Islam Centre for Higher Education, Kumaracoil, Tamilnadu, India*

[3]*Department of Aerospace Engineering, Noorul Islam Centre for Higher Education, Kumaracoil, Tamilnadu, India*

ABSTRACT

The Aluminium alloy 7075 and Magnesium alloy ZE42 plates of 6 mm thickness are welded in the circular butt joint division by friction stir welding (FSW) process, utilizing vertical processing machine. Method parameters, for example, welding maximum speed and FSW rotational speed assume an essential part to acquire a superior weld joint for different metals/materials. The contact stir welding device is one of the basic parts to the achievement of this procedure. It comprises a tube shaped shoulder and a stick with various geometry. In the test work, the said apparatus has been outlined with a barrel shaped stick having four unique geometries for erosion mix welding of the disparate roundabout metal plates. Welding has been completed at welding speed changing from 10 to 40 mm/min and FSW rotational speed from 950 to 1500 rpm. Effects of progression parameters on butt welded circular joint were investigated for weld strength. In this research work, it is found that the welded joint between dissimilar metals alloys Al7075 and Mg ZE42 is framed utilizing FSW by choosing the appropriate device stick profile and welding parameters. It is recommended that friction welding of Aluminum composite and Magnesium compound with tapered butt joint geometry would be helpful later on for vehicle applications by getting the advantages from every material practically.

KEYWORDS: Friction Stir Welding (FSW), Dissimilar Alloys, 7075 Aluminium Alloy & ZE42 Magnesium Alloy & Weld Strength

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Original Article

INTRODUCTION

Friction Stir Welding is a solid-state process in which the metal parts are joined without reaching melting point. Different tool use FSW method and was invented by Wayne Thomas at TWI (The Welding Institute), and the first patent applications were filed in the UK in December 1991[1]. A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates (rectangular or circular) to be joined and traversed along the line (arc in case of circular joint) of the joint. The tool serves two primary functions: (a) heating of work pieces (plates), and (b) movement of material between two materials in amushy state to produce a joint. The major contrast between traditional combination welding procedures and the strong state FSW method is that no warmth is added to the 'framework' in the later; rather feat is produced inside by methods for contact in the apparatus, material interface bringing about the plastic twisting of the material around the mix zone [2,3]. The warming is expert by grating between the apparatus and the workpiece surfaces and coming about plastic disfigurement of workpiece prompts a union past the instrument. The limited warming relaxes the material around the stick and mix of hardware revolution and interpretation prompts development of material from the front of the stick to the back of the stick. Because of this procedure, a joint is created in 'strong state'. In view of

different geometrical highlights of the device [4, 5], the material development around the stick can be very mind boggling [6] During FSW process, the material experiences serious plastic disfigurement at hoisted temperature, bringing about age of fine compared gem grains. Compared grains can, now and again, be a sign for recrystallization and it can be accomplished by warm created because of rubbing between edges of the joint [7]. The fine microstructure in contact blend weld joint delivers great mechanical properties [8]. A schematic of the procedure is introduced in Figure. 1.

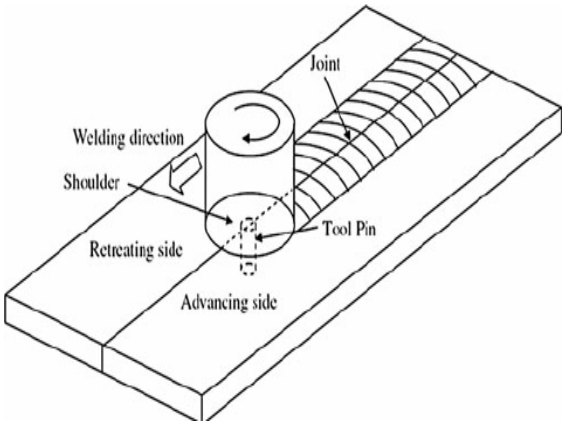

Figure 1: Schematic Diagram of FSW

Friction Stir Welding (FSW) can be considered as a green technology [9] because no gases evolve during the process. Also, there are no toxic fumes or smokes produced during or after the welding process. The process is energy efficient and environmentally friendly [10]. Normally metals and alloys are joined by fusion welding process; particularly welded joints of materials having low weldability may be found with welding defects. Some Al, Cu and Mg alloy series are not at all fusion weldable, and therefore, friction stir welding is useful to join such metallic materials [11].

FSW OF DISSIMILAR MATERIALS

Research studies on dissimilar metal friction stir welds are hereby highlighted and presented in this section. A joining criterion for lap welding of dissimilar Aluminium and stainless steel has been achieved [6]. Successful welds of Aluminium and Copper with good joint integrities have also been reported [8]. Also, good weld joint efficiency in dissimilar joints between Mildsteel and AA6082 Aluminium alloy has been achieved [9]. Other successful dissimilar material welded joints using the FSW process include Aluminium & Magnesium [3] and Steel & Titanium alloy [4], Aluminium & Titanium [13], Mild Steel and Copper Bronze [14]. This review reveals that a lot of potential exists to successfully join dissimilar materials using the FSW process.

METHODOLOGY OF EXPERIMENTAL PROCESS

Since most of the experimental work in the field of friction stir welding of dissimilar metals or alloys has been carried out by making straight butt joints between flat plates using different tool pin profiles by different researchers. It is observed that the circular butt joint between dissimilar metals or alloys are rarely performed using friction stir welding. Therefore, the present work has been carried out for friction stir welding of Aluminium alloy 7075 and Magnesium alloy ZE42 for creating circular butt joint using the welding parameters as shown using different tool pin profiles.

EXPERIMENTAL PROCESS

Circularly or peripherally welded joint of dissimilar alloys such as AA7075 Al alloy and ZE42 Mg alloy using

friction stirwelding using vertical milling machine have been produced. The Aluminium AA7075 alloy plate of 150 mm outer diameter x 60 mminner diameter x 6 mm thick was welded to the Magnesium ZE42 alloy plate of size 65 mm diameter x 6 mm thick. Theactual set up with VMC is shown in Figure 2.

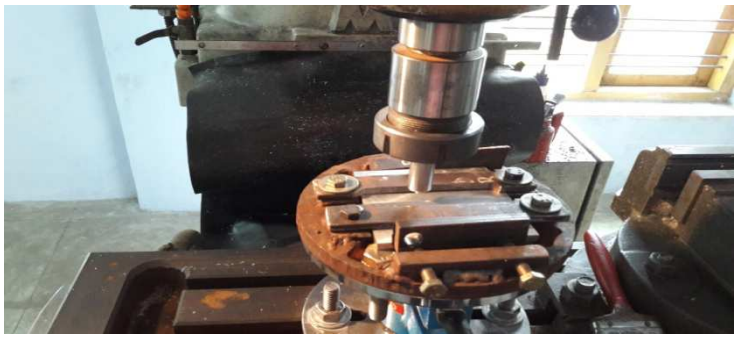

Figure 2: Experimental Setup on VMC Machine

FSW MACHINE SELECTION

The Vertical Milling Machine. has been used for friction stir welding. Two dissimilar plates of the said alloys arranged on the machine bed using fixture support as shown in Figure 3 were welded with different tools having various tool pin geometries and material types.

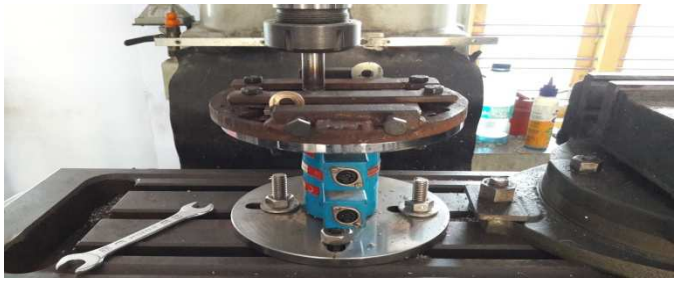

Figure 3: CNC Vertical Milling Machine

DESIGN OF FSW TOOL

The apparatus, material is chosen according to a review of research papers demonstrating the utilization of steel devices for plate materials, for example, Aluminum or Magnesium combinations, and Aluminum lattice composites (AMCs) generally welded by FSW. Steel apparatuses have likewise been utilized for the joining of divergent materials in both lap and butt joint designs. These experimental analyses were performed utilizing instrument steel-H13 and HCHCr with various tool profiles. The apparatus steel-H13 having synthetic piece with more carbon gratified was solidified in the wake of making the device designs for decreasing device wear amid FSW process.

Table 1: Tool Design

Sr No	Shoulder Diameter (D) mm	Shoulder Length(L) mm	Pin Diameter (d)mm	Pin Length(L)mm	Tool Material	Tool Pin Profile
A	16	20	6	3.5	HSS	Cylindrical Threaded Pin
B	18	40	4	4.0	H13	Tapered Threaded Pin
C	20	30	5	3.5	H13	Circular Threaded Pin

Table 1: Contd.,						
D	24	40	6	2.3	HCHCr	Cylindrical Threaded Pin
E	26	40	5	3.7	H13	Cylindrical Threaded Pin

DIFFERENT TOOL GEOMETRY WITH ITS MATERIAL

WELDING PARAMETERS

For the three different tool geometries the range of tool rotational speed and welding speed was selected as shown in Table 2. The choices of feed rate and rotational speed are crucial for the heat generation. In order to create good flow of the material around the tool pin, the forces on the tool should be minimum. The ratio of feed rate of rotational speed is usually reduced to a single parameter referred to as pitch. The properties of the welds are usually related to the pitch, which is believed to be an important parameter in FSW[7].

Table 2: Welding Parameters

Alloy	Rotational speed, rpm	Welding speed, mm/min
AA7075 and ZE42 alloy	950 to 1500	10 to 40

The minimum and maximum values of the welding parameters, the tool rotational speed and welding speed, were varied for different experiments as shown in table 3 below and friction stir welding for dissimilar metal alloys AA7075 and Mg ZE42 was carried out with two circular plates of size 200 mm outer diameter x 95 mm inner diameter x 6 mm thick and 95 mm diameter x 6 mm thick respectively.

Table 3: The Variations in Experimental Parameters

Exp No	Parameters		Tool	Welded side	Welding quality
	Speed (rpm)	Feed (mm/min)			
1	1400	40	A	Up	Partially Good
2	950	30	D	Down	Partially Good
3	1200	80	E	Both side	Poor
4	1000	15	C	down	Poor
5	1150	10	B	Both side	Good
6	1350	20	D	Up	Partially Good
7	1050	60	C	Down	Poor

RESULTS AND DISCUSSIONS

Cylindrical shaped pin was utilized with most elevated welding constraints. For this situation, the plates were not welded effectively because of Path of welding; stick geometry utilized amid FSW and Higher benefit of welding parameter, being the prime reason. Another analysis was completed effectively utilizing tube shaped strung instrument stick outline 'B' and strung stick device was discovered great amid the test. The conceivable explanations behind instrument bind are higher estimation of welding rate of 80 mm/min, Tool material being HCHCr. Testing for FSW with device outline 'C' brought about the disappointment of welding as apparatus got broken. In the present case, apparatus couldn't avoid pivotal load and stick got broken because of too high load along the z-hub. Device outline 'E' is utilized to weld Aluminum and ZE42 Magnesium with various parameters of hardware as can be seen in table 5. Welding occurred with less surface complete (large scale level perception) in the event of FSW utilizing apparatus plan 'C'. Figure 4 demonstrates the plates welded by utilizing instrument plan 'C'. It demonstrates the best possible weld zones, while

utilizing enhanced parameters for the trials.

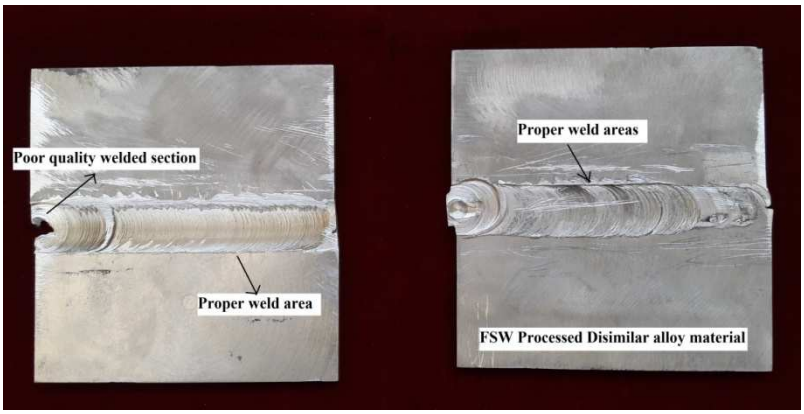

Figure 4: Welded Plates of Dissimilar Alloys Using Same Parameters

TENSILE TEST OF WELDED PLATE

Universal Tensile Testing Machine was used to find the variation between during tensile strength. FSW processed plates are assembled as per mandatory dimensions with UTM machine by typical specimen as shown in figure 8(a) below. Figure shows the sample welded at 1200 rpm and 80 mm/min failed under tensile testing. The tensile strength of welded joints for different experiments number is shown in table 4 in terms of tensile loads.

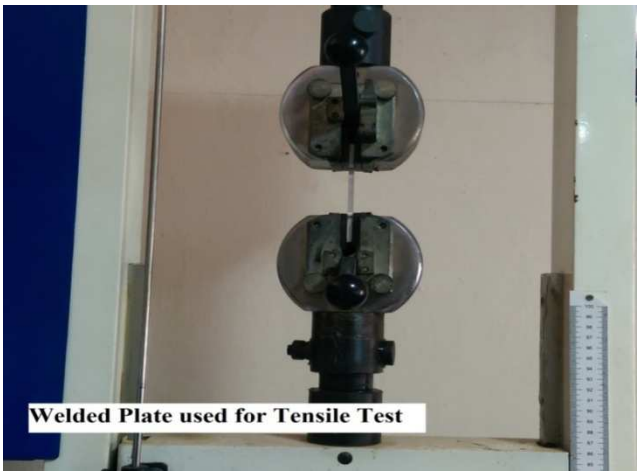

Figure 5: Tensile Testing of Welded Plate

Table 4: The Tensile Test Results with Welding Parameters

Weld No	Weld Plate	Tool Rotational Speed (rpm)	Welding Speed (mm/min)	Tool	Tool Tensile Load (N)	Load (kgf)
1	Peripheral	1200	35	Threaded pin tool	1850	200
2	Linear	1250	25	Threaded pin tool	1050	150
3	Peripheral	1350	10	Threaded pin tool	1250	140
4	Linear	1500	30	Threaded pin tool	1280	130

CONCLUSION

In the present study, within the range of experimental conditions, the following conclusions are made, which can be useful for Friction stir welding of circular butt weld joint between Aluminium alloy AA7075 and Magnesium alloy ZE42.

- AL 7075 and Mg ZE42 can be welded using FSW by proper selection of tool pin profile and welding parameters.
- Different tool designs and specifications affect the appearance as well as properties of welded joint as the way of welding is round about, more troubles have been confronted contrasted with direct way welding.
- The most compelling parameters were observed during FSW process rotational speed of 1150 rpm and welding speed of 10 mm/min were observed to be the most compelling parameters, influencing mechanical properties of roundabout butt weld joint amongst AA7075 and ZE42 when welded by utilizing tube shaped strung pin device of H13 material. The trials that lower estimations of Tool rotational speed and welding speed are better for FSW of unique compounds under thought when utilizing HCHCr device material.

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